

FIRE
EXTINGUISHERS FOR AUTOMOBILES

BY

W. C. GIELOW
E. J. HEPP

ARMOUR INSTITUTE OF TECHNOLOGY

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FIRE EXTINGUISHERS FOR AUTOMOBILES

A THESIS.

Presented by

W. C. Gielow.

E. J. Hepp.

to the

President and Faculty

of

ARMOUR INSTITUTE OF TECHNOLOGY

FOR THE DEGREE OF

BACHELOR OF SCIENCE IN FIRE PROTECTION ENGINEERING.

Having Completed The Prescribed Course of Study In
Fire Protection Engineering.

W. C. Gielow
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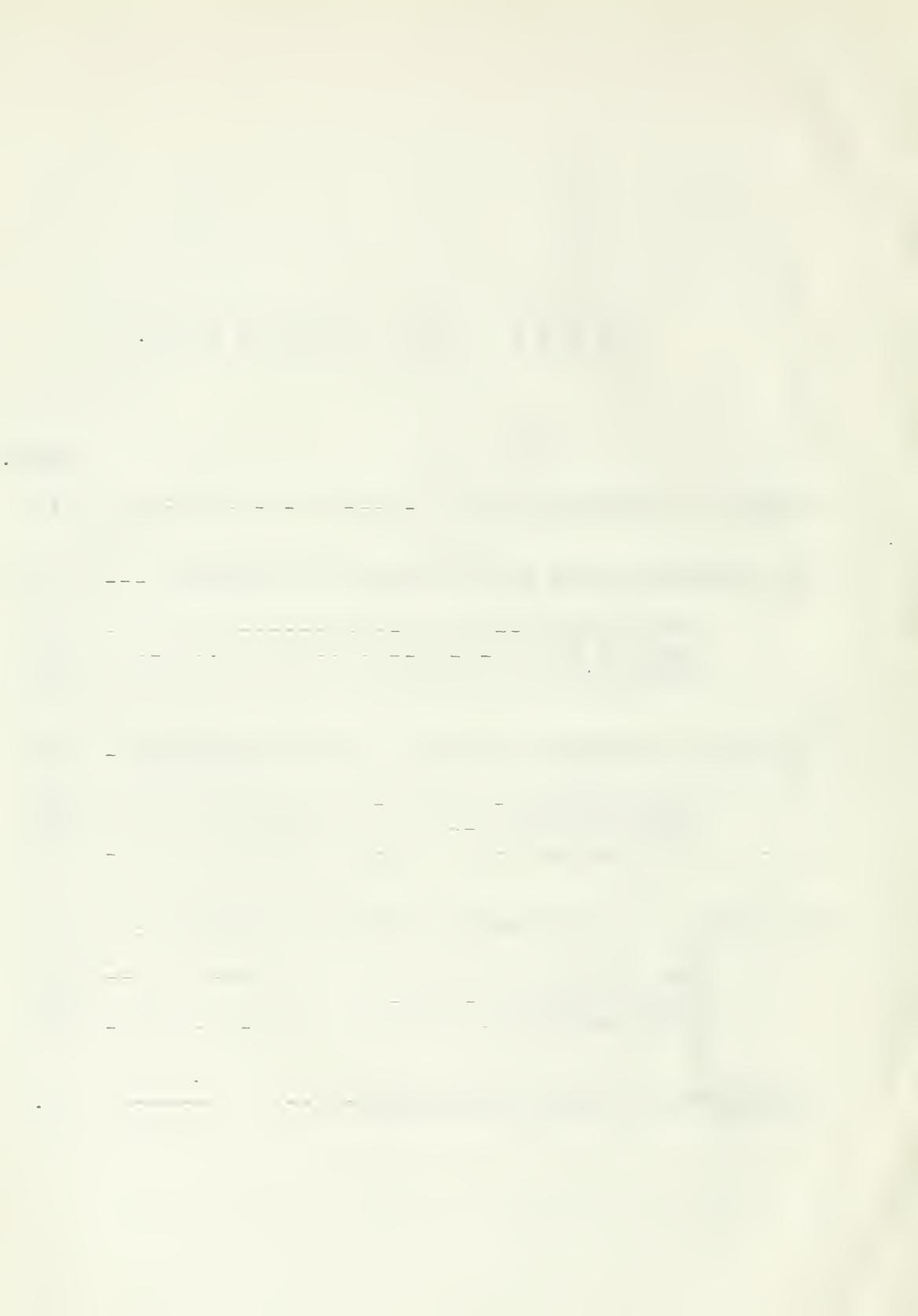
P R E F A C E.

The subject included in the title of this investigation is very broad and in the limited time at our disposal it was impossible to cover the entire range of extinguishers which may be used on automobile fires. The work was therefore confined to tests with three types of extinguishers on incipient automobile fires and conclusions were drawn up taking into consideration the merits or faults of each and a comparison of their merits was made. The account of the test work is preceded by a short discussion of the causes of automobile fires based chiefly upon information obtained from the publications of the National Fire Protection Association.

We are indebted to Professor Taylor and Mr. E.J. Smith for the use of apparatus and for valuable suggestions made while the work was being carried on and take this means of assuring them of our appreciation.

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CAUSES OF AUTOMOBILE FIRES.

The two factors of importance in a consideration of automobile fires and their causes, are the materials present, which furnish fuel for the combustion, and the source of ignition. These two factors are considered separately in this introductory discussion so as to avoid as far as possible, a repetition of each element of one in connection with the various elements of the other.

The combustible materials present in an automobile include parts of the body and upholstering, fuel for power, lighting and heating, and combustible materials introduced into the car temporarily.

The tendency of many automobile manufacturers seems to be to reduce the amount of combustible materials in the body to a minimum. Wood is used in electric cars throughout the entire body, but in gasolene cars the use of this material is frequently restricted to the floor boards, seats, wheels and for reinforcing sheet metal parts of the body such as the doors.

The fuel used for power, both in steam cars and in those propelled by internal combustion engines, is generally gasolene, which is very volatile at ordinary temperatures, and burns readily when ignited. The gasolene supply is kept in a sheet metal tank and exposure of the fuel occurs when the tank is being filled, the hazard being materially increased if the gasolene overflows through the fill opening. The gasolene is led from the tank to the carbureter generally through seamless copper tubing, and may be exposed by leakage through a defective joint in the line. The carbureter is a somewhat delicate device which may become deranged so as to permit a constant leakage of the fuel.

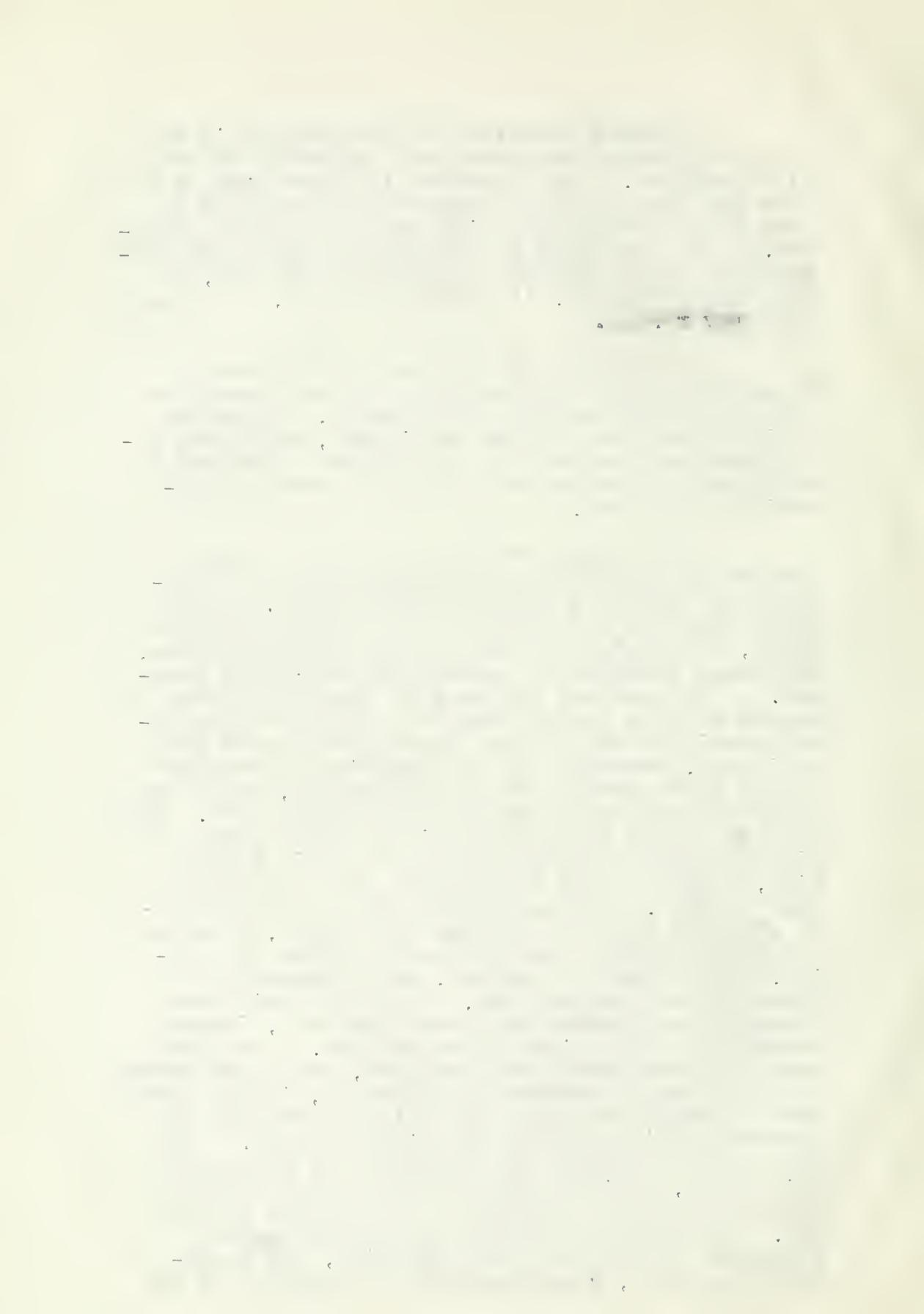
The lighting systems of automobiles do not furnish very much combustible material and are of greater importance in providing a source of ignition than in providing inflammable material. Three types of lighting systems are used on automobiles acetylene, kerosene and electric. Two systems are used for supplying the acetylene to the lamps; in one the automobile carries a generator, which manufactures the acetylene as required from calcium carbide and water; in the other a tank, containing a fibrous filler and acetaldehyde or acetone, carries the acetylene in solution. In the latter system the acetylene is manufactured at a central station and forced into the tank at a pressure of about 250 pounds per square inch at 70 degrees Fahrenheit. Neither of these systems presents a very hazardous condition, under normal conditions, but a failure of some part may result in the escape of acetylene which when ignited will give a very hot flame. A fire in other materials of the car may cause a hazardous condition in either system, the former by the failure of a joint so as to allow the water and carbide to unite to form acetylene and the latter by the fusing of a composition plug inserted at one end of the tank, which will fuse at a temperature of about 200 degrees Fahrenheit so as to allow the escape of the acetylene before the high temperature causes a dangerous increase in the pressure. Kerosene lamps are used on automobiles, but as the quantity of fuel is very small they do not furnish much fuel for combustion. Electric lighting systems furnish a negligible supply of combustible material.

Heaters consisting of a container with burning charcoal or soft coal briquettes in a drawer, furnish some fuel but are considered more important as a source of ignition than as a provider of material. Portable kerosene stoves are frequently used as heaters and, if tipped over, so as to spill oil on other inflammable parts of the car the danger of ignition of those parts is increased materially.

A common practice in some garages is to clean the engine and other oily parts of the car with gasolene. The gasolene is discharged in a fine jet from a nozzle connected by means of a hose with a tank containing the fluid under pressure. The condition presented, with gasolene distributed on the surface of parts of the car, is very hazardous and, if ignition occurs, a serious fire may result.

The sources of ignition of the burning materials found in automobiles are very numerous and may be divided into two classes, the causes of ignition found in the car itself, and those appliances or hazards found in garages which may originate a fire in some of the combustible material in the car.

The factors which are generally found on automobiles and which may cause ignition of combustible materials are considered first. The power plant of each type of car presents hazards which, both under abnormal and normal conditions, may cause ignition of combustible materials present. In gasolene cars one of the most common causes of fire is ignition of a charge in the intake manifold while being drawn into one of the cylinders, resulting in the ignition of gasolene in the float chamber of the carburetor, or of any combustible material near the air inlet port. The exhaust piping of an automobile becomes very hot with the engine running and if it is in contact with, or very close to woodwork the wood may become ignited. An unexploded charge is frequently expelled into the exhaust piping and, when the hot gases from the next explosion enter the piping, this charge is ignited, and frequently a flame several inches long, which may ignite any combustible material underneath the car, issues through the tail pipe of the muffler. In steam cars the most hazardous condition, which may cause the ignition of combustible material, is the flame used to heat the boiler and which is burning continuously while the car is being operated. In the event of leakage of gasolene at a point near this flame, ignition might result which would be communicated very readily to other parts of the car. In electric cars and in the electrical equipment of gasolene cars sparking, due to defective wiring, loose contacts or sparking at the



commutator may cause ignition of inflammable material. This danger is probably of greater importance in gasoline than in electric cars for three reasons; the tendency toward electric lighting, ignition, starting and heating necessitates the use of several generators and a motor as well as a storage battery so the number of points at which ignition may occur is increased; the vibration of the engine may result in loosening electrical connections and; gasoline, a fuel with a low ignition temperature is present.

The lighting systems used on automobiles sometimes cause fires. The electric system is probably the safest as it presents the hazard of sparking only, as noted in the previous paragraph. Acetylene and kerosene lamps present the danger due to an open flame and their chief hazard is the danger of ignition of gasoline vapors. The tanks of automobiles are sometimes filled with the lamps burning and ignition of the gasoline vapors given off has resulted in disastrous fires. Searching for gasoline leaks with one of the kerosene lamps has also resulted in ignition of the vapors.

Several types of heating systems are used on automobiles with closed bodies. Portable oil heaters are probably the most hazardous as they furnish not only a means of ignition but also contain a quantity of fuel which might be discharged on the floor boards. Heaters, consisting of a sheet metal case, provided with a drawer containing glowing charcoal or soft coal briquettes, are used quite extensively, and they may be the cause of fire in the car. The exhaust from the gasoline engine may, on some cars, be diverted so as to pass through coils to heat the interior. These coils may cause the ignition of parcels or clothing carelessly laid on them, or of wood used in the construction of the body and with which they may be in contact. Electric heaters when properly installed and pro-

tected from contact with inflammable materials are the least hazardous of the types used.

Some of the sources of ignition which are not connected with the car, but are found in garages and repair shops and may result in burning of the car are considered here very briefly. Hazards such as heating and lighting are found in most garages and they are especially hazardous if an open flame is used. Incandescent lamps and open arc lights have caused fires in garages, the former by being dropped and exposing the red hot filament and the latter by dropping particles of red hot carbon. Oil heaters and kerosene lamps are very hazardous. Gasoline blow torches and oxy-acetylene welding outfits are frequently used in repairing automobiles and may cause ignition of gasoline vapors. Vulcanizers especially those using an open flame to produce the heat, are frequently used and present some hazard. Oily waste if left undisturbed for some time is liable to become ignited spontaneously and may be considered a source of ignition. One of the common causes of fire in garages is a burning match carelessly thrown on combustible materials.

THE WOLVERINE FIRE EXTINGUISHER.

DESCRIPTION.-

This extinguisher shown by Figure 2 consists essentially of a cylindrical cardboard tube with tinned sheet metal ends and filled with a very finely ground powder.

The cylindrical tube is made up of two strips of cardboard which are wound helically one above the other and pasted together. A paper sheet bearing the printing is pasted on the outside. The tube is 22 inches long, the outside diameter 2 inches and the inside diameter 1-7/8 inches.

The edges of the tinned ends are crimped over the ends of the cardboard tube. The lower end is a disk completely closing the tube. The upper end is in two parts the edge of one in the form of a ring is crimped to the top of the cylinder and is provided with a circular opening for filling with and discharging the powder, the other is a cover dished to a depth of about 1/4 inch and a ring, used for supporting the extinguisher is attached to it.

The powder is very finely ground, is dark grey in color and was found to have the following composition.-

Sodium Bi-Carbonate -----	64.0%
Sodium Carbonate -----	7.0%
Water Insoluble Residue -----	25.4%
(Consisting principally of)	
(silica powder with a small)	
(amount of carbon, iron, etc.)	
Moisture (by difference) -----	3.6%

DATA OF TESTS
MADE TO DETERMINE THE EXTINGUISHING
EFFICIENCY OF THE WOLVERINE DRY POWDER EXTINGUISHER.

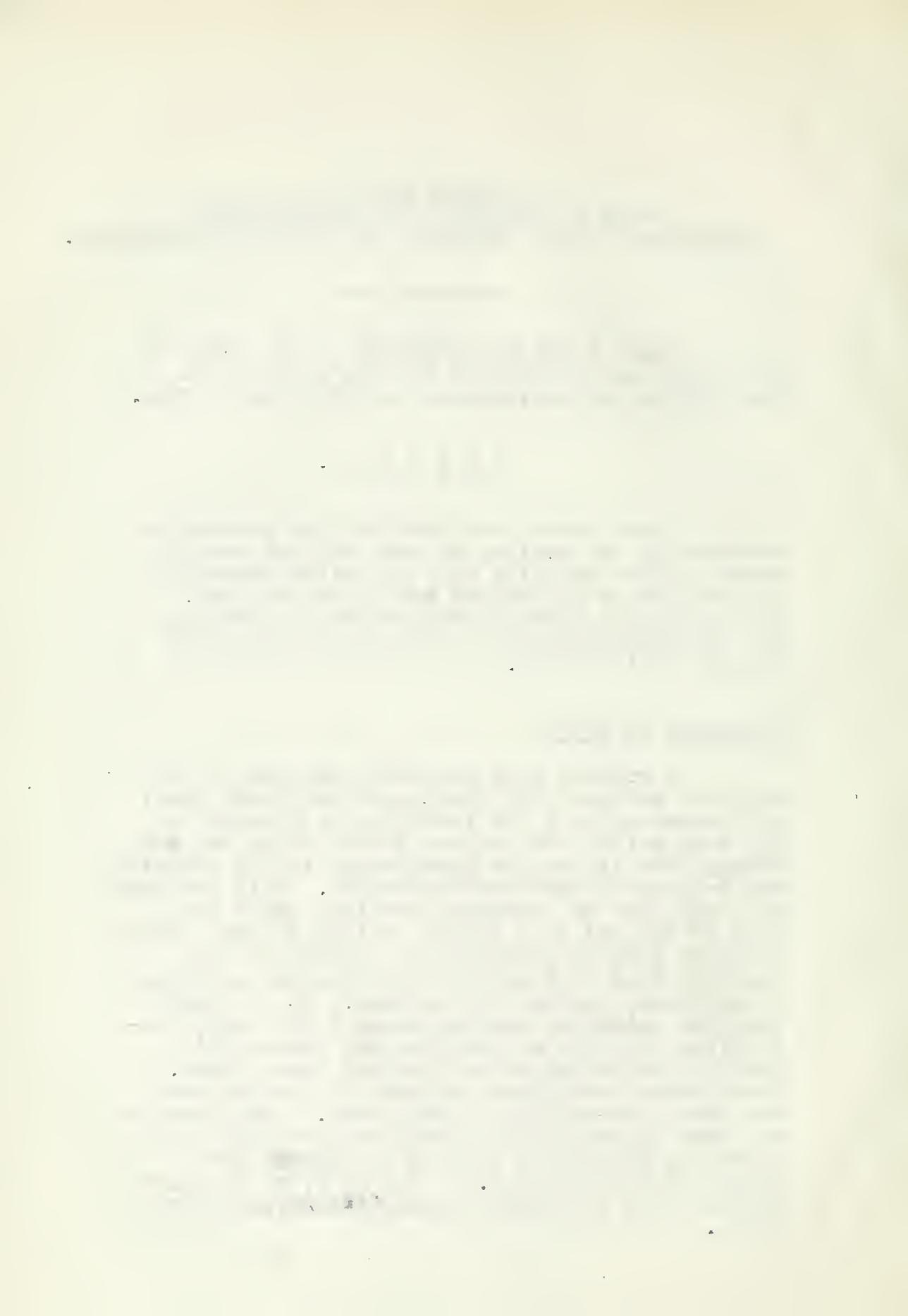
These tests are numbered in the order in which they were performed but are arranged in four groups for convenience in referring to them.

G R O U P I.

These tests were made for the purpose of determining the ability of this extinguisher to control fires starting with a limited quantity of gasoline on the engine and in the mud pan. This condition might be the result of cleaning the car with gasoline or the gasoline might be spilled accidentally.

CONDITION OF TEST.-

A gravity feed gasoline tank was set up with the bottom 4-1/2 feet above the floor level and connected by a 1/8 inch pipe to a length of 1/8 inch hollow wire copper tubing which was led through one of the air passageways in the radiator and terminated near the carbureter. This arrangement was used to discharge gasoline under the hood of the car in a manner similar to that which might in practice result from a break in the gasoline line or a defective carbureter allowing a continuous leakage of gasoline. In the tests included under the heading Group I the valve controlling the flow of gasoline was opened wide for a definite length of time and then closed. Under these conditions the rate of flow of fuel was about one-half pint per minute. The gasoline was then ignited with a match and the fire attacked by means of a tube of the powder immediately after ignition. The hood, on the carbureter side was open throughout this series of tests.



Neither the engine nor fan were running while these tests were being made. After each test the powder was blown, from the engine, carbureter and mud pan, as thoroughly as possible by means of an air blast which also assisted in evaporating any gasoline remaining.

TEST NO. 1.

Duration of gasoline flow 4 minutes. A small quantity dripping to floor. Tube No. 1 was used immediately after ignition. Operator attacked and checked fire about carbureter and in front part of the mud pan. The fire in the mud pan was then attacked from underneath the car. Extinguisher exhausted. Fire was not controlled. Weight of powder used: 2 pounds 2.40 ozs.

TEST NO. 2. (Repetition of Test No. 1.)

Tube No. 2 was used immediately after ignition. Operator attacked the fire in the same way as in Test No. 1 but failed to control the fire. Extinguisher exhausted. Weight of powder used: 2 pounds 1.77 ounces.

TEST NO. 3. (Repetition of Test No. 1.)

Tube No. 3 was used immediately after ignition. The fire was attacked in the same way as in tests No. 1 and No. 2, but was not controlled. Extinguisher exhausted. Weight of powder used: 2 pounds 2.74 ounces.

TEST NO. 5. (Repetition of Test No. 1.)

Two tubes being used. Tube No. 5 was used immediately after ignition and tube No. 6

when No. 5 was exhausted. The operator alternated his attack on the fire in the front part of the mud pan and then on the fire in the back part. The fire was checked about the engine several times, but started up each time when the operator attacked the fire at the rear of the mud pan.

Weight of powder used: No. 5,- 2 pounds 3.01 ozs.

No. 6,- 2 pounds 3.10 ozs.

Total - 4 pounds 6.11 ozs.

G R O U P II.

The tests in this group were made for the purpose of determining the ability of this extinguisher to control fires starting after the gasolene line had become broken or the carbureter deranged so as to leak.

CONDITION OF TESTS.-

The arrangement of the apparatus including the automobile, the gravity tank and tubing was the same as for tests outlined under Group I. In this series, however, the gasolene was allowed to flow, with the valve wide open, through out each test and was shut off only when the extinguisher used was exhausted or the fire was put out. The gasolene in all these tests was allowed to drip on the carbureter and fires of various magnitudes were attacked with the extinguishers, some being confined entirely to gasolene on the carbureter and piping and others with gasolene on the carbureter, mud pan and floor. Neither the engine nor fan were running while these tests were being made. After each test the powder was blown from the engine, carbureter and mud pan, as thoroughly as possible by means of an air blast which also assisted in evaporating any gasolene remaining.

TEST NO. 4.

The gasolene was ignited after flow had continued 60 seconds. Tube No. 4 was used immediately after ignition. The operator attacked the fire about the carbureter and when flames were confined to back end of mud pan the attack was transferred to that point.

Extinguisher exhausted at 1 minute 15 seconds. The flames were not extinguished and the flowing gasolene re-ignited.

Weight of powder used: 2 pounds, 3.92 ozs.

TEST NO. 6.

The gasolene was ignited immediately upon starting flow. Tube No. 7 was immediately after ignition. Flames were confined to carbureter and to a small area of the mud pan. Fire extinguished in 13 seconds.

Weight of powder used: 6.59 ounces.

TEST NO. 7.

The gasolene was ignited after flow had continued 30 seconds. Tube No. 8 was used immediately after ignition. The fire extended to the back end of the mud pan and was checked about the carbureter but the flowing gasolene re-ignited when attack was transferred to back end of pan. The extinguisher was exhausted without controlling the fire.

Weight of powder used: 2 pounds, 3.12 ozs.

TEST NO. 8.

The gasolene was ignited after flow had continued 26 seconds. Tube No. 9 was used immediately after ignition. The flames were con-

#14..

fined to the front part of the mud pan because of the fact that the carbureter and pan were quite hot as a result of the previous test and a large proportion of the gasolene was vaporized. The fire was extinguished at 51 seconds after starting flow.

Weight of powder used: 2 pounds 5.36 ozs.

TEST NO. 9.

The gasolene was ignited after flow had continued 30 seconds. The flow of gasolene was shut off at the time of ignition and tube No. 10 was used immediately. The fire was extinguished at 37 seconds after flow was started.

Weight of powder used: 5.20 ounces.

TEST NO. 10.

The gasolene was ignited after flow had continued 1 minute 6 seconds.

Tube No. 11 was used immediately after ignition. The operator attacked the fire about the carbureter and, when checked there, at the back end of the mud pan. The fire was not controlled, the extinguisher being exhausted 1 minute 50 seconds after starting flow.

Weight of powder used: 2 pounds 3.70 ozs.

TEST NO. 11.

The gasolene was ignited after flow had continued 20 seconds. Tube No. 1 was used immediately after ignition. Owing to the fact that the quantity of gasolene which had been discharged was small the fire was confined to the carbureter and the front part of the mud pan and was extinguished 26 seconds after starting the flow.

Weight of powder used: 5.56 ounces.

TEST NO. 12.

The gasolene was ignited after flow had continued 60 seconds. Tube No. 2 was used immediately after ignition. The fire extended from the gasolene about the carbureter to that which had dripped on the floor. The fire about the carbureter was attacked and when checked at this point the operator applied the powder to the fire at the back end of the mud pan and on the floor. The flames flashed back to the gasolene flowing on the carbureter and the extinguisher was exhausted 1 minute, 23 seconds after starting flow, without controlling the fire.

Weight of powder used: 2 pounds 2.73 ozs.

TEST NO. 13.
(Repetition of Test No. 12)

Tube No. 3 was used. Fire extended over same area. Extinguisher exhausted 1 minute 23 seconds after starting flow of gasolene. Fire not controlled.

Weight of powder used: 2 pounds 3.50 ozs.

TEST NO. 15.

The gasolene was ignited after flow had continued 45 seconds.

Tube No. 5 was used immediately after ignition. The fire was confined to the gasolene on the carbureter and in the mud pan. The fire about the carbureter was checked but the flowing gasolene re-ignited when the fire at the back end of the mud pan was attacked. The ex-

tinguisher was exhausted 1 minute 4 seconds after flow was started. The fire was not controlled.

Weight of powder used: 2 pounds 3.19 ozs.

TEST NO. 16.
(Repetition of Test No. 15.)

Tube No. 6 was used immediately after ignition. The fire was of the same magnitude as in Test No. 15 and was not controlled. The extinguisher was exhausted 1 minute 9 seconds after starting flow.

Weight of powder used: 2 pounds 3.03 ozs.

TEST NO. 17.

The gasolene was ignited after flow had continued 30 seconds. Tube No. 7 was used 48 seconds after flow was started. The fire was confined to the gasolene in the mud pan and about the carbureter. The extinguisher was exhausted at 1 minute 4 seconds, the fire not being controlled.

Weight of powder used: 2 pounds 3.73 ozs.

TEST NO. 18.

The gasolene was ignited after flow had continued 30 seconds. Tube No. 8 was used 40 seconds after starting flow. The fire was confined to gasolene on the carbureter and in the mud pan. The extinguisher was exhausted at 52 seconds, the fire not being controlled.

Weight of powder used: 2 pounds 3.53 ozs.

TEST NO. 19.

The gasolene was ignited immediately

upon starting the flow. Tube No. 9 was used 30 seconds after starting the flow. The fire was confined to gasolene on the carbureter and in the mud pan. The extinguisher was exhausted at 45 seconds the fire not being controlled.

Weight of powder used: 2 pounds 5.68 ozs.

TEST NO. 20.

Before making this test, the engine, carbureter and pan were heated by burning gasolene on these parts then when this preliminary fire was out the flow was started and ignited immediately. Tube No. 10 was used 31 seconds after starting the flow. The fire was confined almost entirely to the gasolene on the carbureter, it being vaporized so rapidly that but very little dripped in the pan. Fire was extinguished 36 seconds after starting flow.

Weight of powder used: 1 pound 0.69 ozs.

TEST NO. 21.

The engine etc., were heated before the test as in No. 20. The gasolene was ignited immediately upon starting flow, and tube No. 11 was used 60 seconds after starting flow. The fire was confined to gasolene on the carbureter, the flames extending up about 4 feet above the carbureter. The fire was extinguished 66 seconds after starting flow.

Weight of powder used: 1 pound 4.13 ozs.

TEST NO. 22. (Repetition of Test No. 21.)

Tube No. 1 was used. The fire was extinguished 3 seconds after applying the extinguisher.

Weight of powder used: 13.83 ounces.

G R O U P III.

The apparatus was arranged as in Groups I and II. Dirty lubricating oil was sprinkled on the engine and in the pan as indicated in the description of each test. Neither the engine nor fan were running while these tests were being made. After each test the powder was blown from the engine, carbureter and mud pan, as thoroughly as possible by means of an air blast which also assisted in evaporating any gasolene remaining.

TEST NO. 14.

The hood on the carbureter side was open during this test. One half pint of lubricating oil was spread on the engine and adjacent piping. A small quantity of gasolene was then distributed on the oil to furnish a means of ignition. This was ignited but the lubricating oil did not burn very well. After burning 2 minutes 45 seconds the valve regulating the gasolene flow was opened wide and at 2 minutes 54 seconds tube No. 4 was used.

The fire was out at 3:00 minutes after ignition. Weight of powder used: 15.84 ozs.

TEST NO. 23.

The hood was entirely removed from the car for this test and the engine, carbureter and other adjacent parts of the car were heated by burning gasolene which was sprayed on them and ignited. Then one pint of dirty lubricating oil was sprinkled on the engine and another pint in the mud pan. The gasolene was then allowed to run slowly through the tubing and was sprinkled over the entire engine by moving the end of the tubing about. It was then ignited. When well under way, Tube No. 2 was used, the entire contents, 2 pounds 2.89 ounces, being discharged. The fire was not controlled.

TEST NO. 24
(Repetition of No. 23, except)
(that 2 extinguishers were)
(used.)

Tube No. 3 was used at the time when the fire had reached about the same magnitude as at the time of attack in the preceding test, the entire contents, 2 pounds 3.06 ounces, being used and the fire was then extinguished with tube No. 4, 1 pound 14.13 ounces of the powder being used.

CONCLUSIONS REGARDING THE USE OF THE WOLVERINE DRY POWDER EXTINGUISHER FOR USE ON AUTOMOBILE FIRES.

1.- METHOD OF APPLICATION.-

The method of applying the extinguishing agent which consists of throwing it from a cylindrical container with a sweeping motion, cannot be considered as being effective.

It is difficult to throw the powder accurately and with the desired force upon a fire because the method of discharge affords very little opportunity of taking aim.

The effective range of this type of extinguisher is inherently very short because it is difficult to throw the powder far, the waste of powder increases with the distance thrown and if thrown at long range the powder is retarded by friction with the air to such an extent that the effectiveness of the part reaching the fire is slight. An extinguisher of any type should have a range sufficient to

enable the operator to safely and effectively attack any fire likely to be attained in the time required to bring the extinguisher into action. Automobile fires attain their maximum magnitude within a very short period of time so it is considered essential that an extinguisher designed for use on such fires have a long effective range.

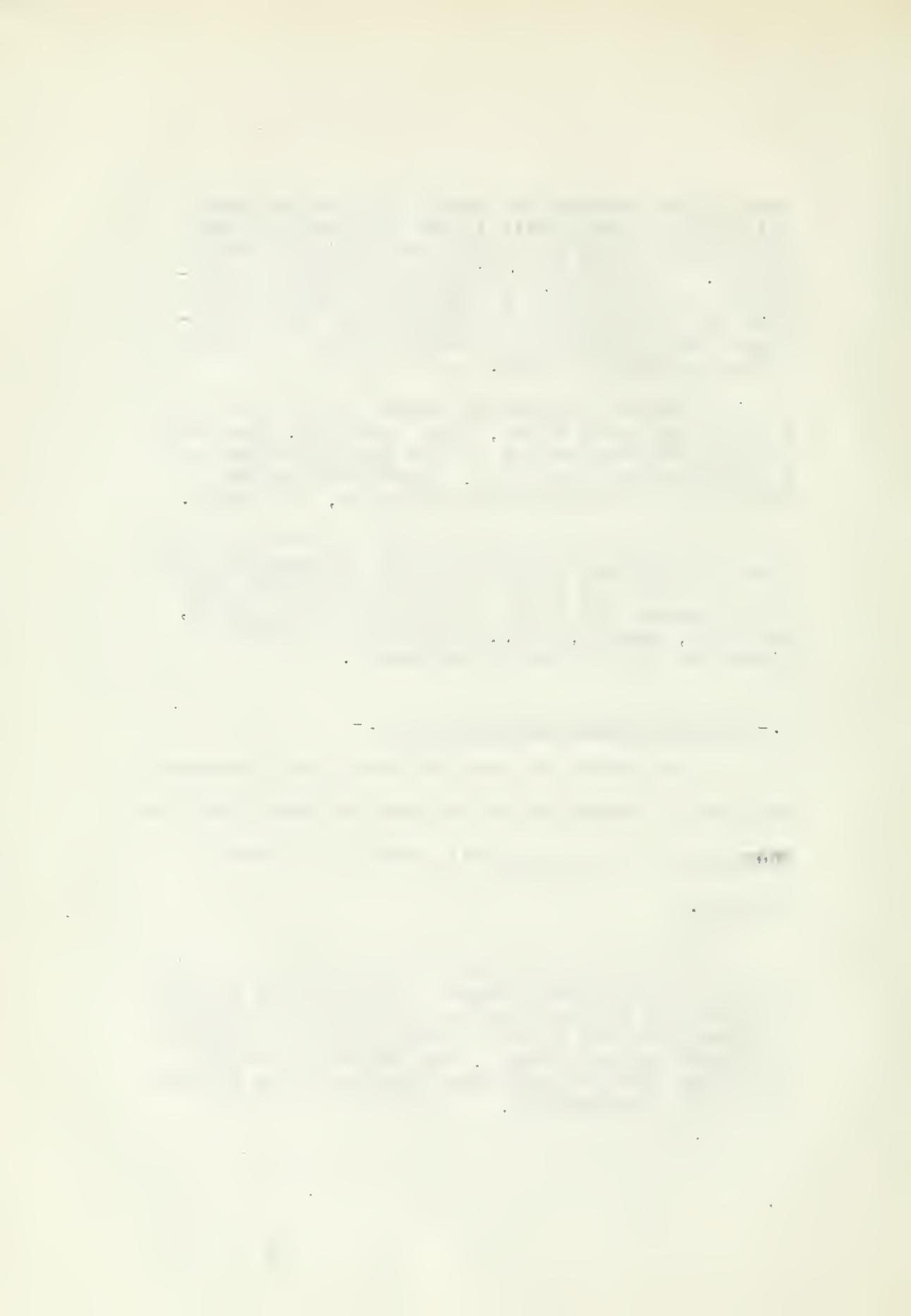
The extinguishing agent is contained in a paper cylinder which, when operated, does not concentrate the powder at the point desired and a large proportion of it, especially in the hands of an inexperienced operator, is wasted.

In automobile fires this objection is of great importance because of the inaccessibility of the points at which the fire may occur and also because the parts of the car as the hood, radiator, engine, etc., hinder the operator in directing the extinguishing agent.

2.- EXTINGUISHING EFFECTIVENESS.-

The tests of this extinguisher indicate that it is effective on automobile fires only when the amount of inflammable material is very limited.

The extinguishing effectiveness of this form of extinguisher seems to be limited almost entirely to the smothering action of the finely divided material with probably a very slightly increased effectiveness, due to the evolution of carbon dioxide gas when the powder is raised to a high temperature.



3.- SUITABILITY FOR USE.-

This extinguisher is not considered suitable for use on automobile fires such as may occur in practice because it is effective only on fires in which the amount of inflammable liquid is very limited, because the use of this extinguisher on a car may result in damage to the wearing parts of the motor and because under certain conditions the extinguisher could not be used.

Tests indicate that owing to the difficulty of applying the powder to the fires liable to occur in automobiles and owing to the ineffectiveness of the powder actually thrown upon such fires but little reliance can be placed on this material to extinguish them.

The chemical analysis of the powder used in these extinguishers indicates that 25.4% is a water insoluble residue principally silica with some carbon, iron, etc. The powder is ground very fine and after the tests it was found, although the engine had been thoroughly cleaned with an air blast, that appreciable quantities of the powder had gotten into the magneto and other parts not thoroughly encased. It is considered very probable that the insoluble residue, particularly the silica would cause abrasion of bearings and other wearing surfaces. The use of this extinguisher on a fire about the engine of an automobile would probably necessitate the dismantling of the engine and cleaning of all the parts.

In case of a fire starting about the engine of a car while the hood is down and attaining such a magnitude that the operator is unable to raise the hood in order to attack it, this extinguisher would be useless.

THE ERWIN AUTOMATIC CHEMICAL FIRE EXTINGUISHER.

DESCRIPTION.

GENERAL.-

This extinguisher illustrated by Figures IV and V consists essentially of a pressure tank, containing the extinguishing fluid, connected by galvanized pipe to a sprinkler head installed at a point under the hood. The fill opening at the top of the tank is closed by a pressure gauge threaded into it. A valve at the bottom of the tank serves to admit the air which is pumped in with an ordinary tire pump. A lever arrangement, shown in Figure IV, permits of manual operation of the device by pushing out the strut of the sprinkler head.

OPERATION.-

The tank is charged with the extinguishing fluid, after removing the pressure gauge, by pouring into it, through a funnel, two quarts of carbon tetrachloride. After replacing the gauge an air pump is threaded on the nipple of the air valve and the pressure in the tank, as indicated by the gauge, is raised to 30 pounds per square inch. The system is now charged and is ready to operate when the solder on the strut of the sprinkler head is fused by heat.

TANK.-

The tank made of pressed steel, shown at 7 in Figure IV is cylindrical in shape with dished ends, the internal dimensions being, diameter 6 inches, length 12 inches and capaci-

ty 1.5 gallons. The tank is tinned inside and outside by the hot process, to protect it from corrosion, and is then nickel plated. Two threaded openings are provided, one the fill opening at the top which is closed with a pressure gauge, and the other at the bottom through which the contents are discharged and the air is admitted.

SPRINKLER HEAD. -

The sprinkler head shown at 9 in Figure IV is a Grinnell head and is designed to operate when the solder reaches a temperature of 286 degrees Fahrenheit.

The head consists essentially of the following:- Frame, strut, deflector, disk and diaphragm. The disk is of bronze and it seats on a 1/2 inch orifice in the aluminum bronze diaphragm which is fitted in the body of the head. It is held in place by a strut which is composed of three parts held together by solder in such a way that the fusing of the solder will allow the collapse of the strut and permit the pressure of the extinguishing fluid to force the disk from its seat. The frame is of phospher bronze and the legs are in tension due to the pressure brought on the strut by the distortion of the diaphragm and the fluid pressure under it. The deflector at the top of the frame serves to distribute the issuing stream.

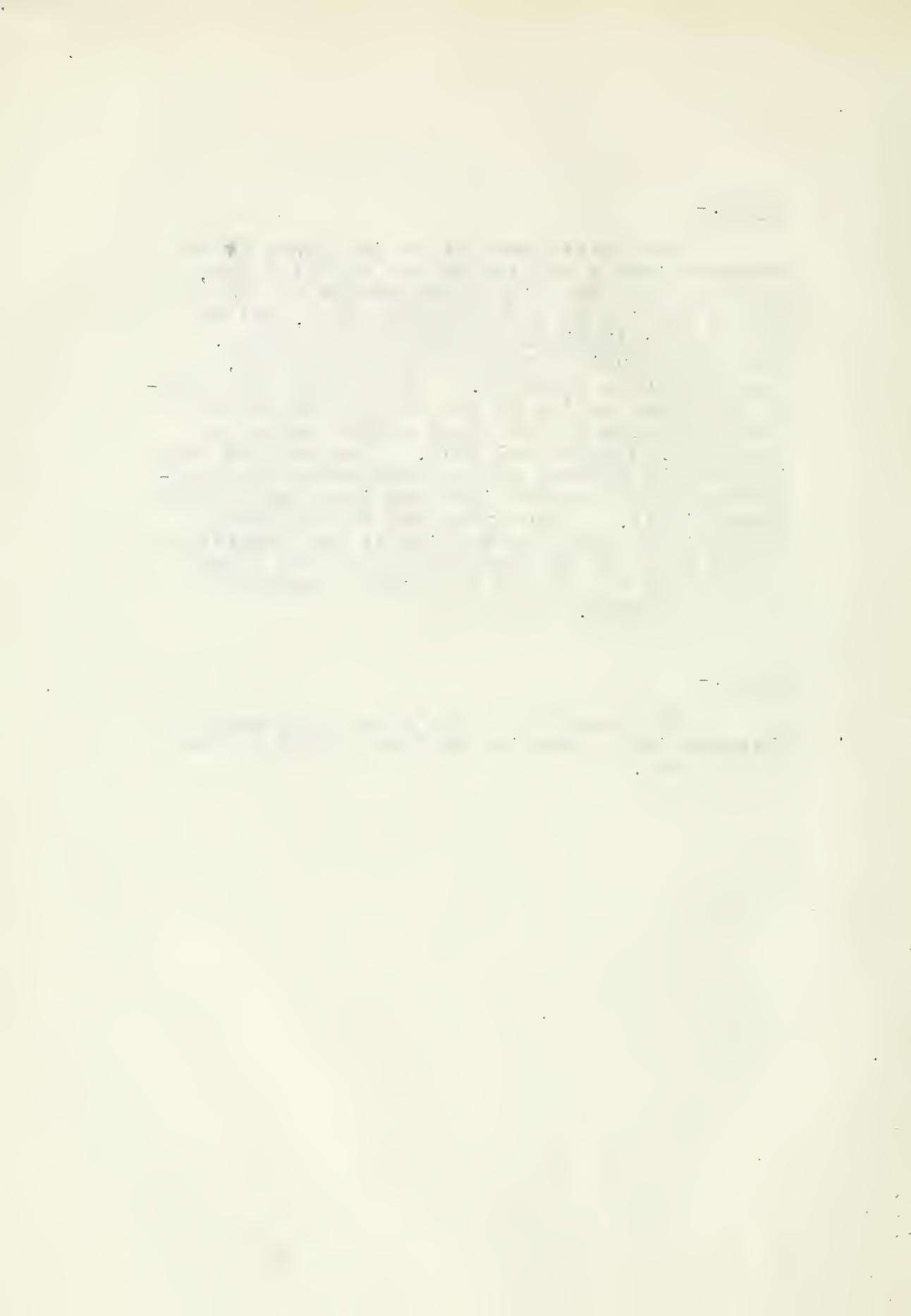
In these tests a bushing with an internal diameter of 1/4-inch was inserted in the inlet orifice of the head so as to increase the time of discharge of the contents of the tank.

VALVE. -

The valve shown at 23 in Figure IV is threaded into a bushing in one arm of a Tee, the other arm of which is connected to the piping leading to the sprinkler head, and the side arm to the outlet orifice in the tank. The valve housing consists of two nipples, connected by a coupling. One nipple is threaded into the bushing in one arm of the Tee and the inner edge of the other nipple serves as a seat for a spherical ball. The ball is held in place by a steel spring compressed by a perforated plug threaded into the inner end of the inner nipple. The outer end of the outer nipple is threaded on the inside and outside so a tire pump can be connected to it and a cap is provided to provide additional security against leakage.

GAUGE. -

The gauge is of the usual type and is threaded into a bushing in the filling orifice of the tank.



DATA OF TESTS MADE TO DETERMINE THE EXTINGUISHING EFFICIENCY OF CARBON TETRACHLORIDE, ON AUTOMOBILE FIRES, WHEN USED IN THE ERWIN AUTOMATIC CHEMICAL FIRE EXTINGUISHER.

CONDITIONS OF TESTS.-

These tests were made in the open air and the automobile used was standing on ground which is quite porous. A gravity feed gasoline tank was set up with the bottom 4-1/2 feet above the ground level and connected by a 1/8 inch pipe to a length of 1/8 inch hollow wire tubing which was led through one of the air passageways in the radiator and terminated above the carbureter. Under these conditions when the valve controlling the flow of gasoline was opened wide the rate of flow of fuel was about one half pint per minute. In these tests the valve was opened wide at the start of the test and was left open until the fire was controlled or it became so large that it was readily apparent that the extinguisher could not control it. The gasoline was ignited with a match after flow had continued a definite length of time, as indicated in the account of each test and the extinguisher operated at the time noted. The hood was down on both sides while these tests were being made, but the fit was very imperfect and as a result the conditions were more severe than would generally be found on cars on which the extinguisher is installed. The sprinkler head was installed on the side opposite the carbureter and therefore was not directly above the hottest flames. In each of these tests the extinguisher was charged with two quarts of carbon tetrachloride and pumped up to a pressure of 30 pounds per square inch.

TEST NO. 1.

Gasolene was ignited after flow had continued 1 minute 30 seconds. At this time the gasolene commenced dripping on the ground from the back end of the mud pan and it was ignited at that point. At 2 minutes 31 seconds extinguisher operated. Fire was extinguished completely with some gasolene remaining in the mud pan. Time of operation of extinguisher about 9 seconds.

TEST NO. 2.

Gasolene on ground was ignited after flow had continued 2 minutes. At 2 minutes 20 seconds the gasolene in the mud pan ignited, the delay in getting in being due to the wind which was blowing. At 3 minutes 10 seconds extinguisher operated. At about 3 minutes 15 seconds the fire in the car was out. At 3 minutes 17 seconds the fire on the ground was out. Time of operation of extinguisher about 9 seconds.

TEST NO. 4.

Gasolene on ground ignited after flow continued 4 minutes. At 4 minutes 8 seconds the gasolene in the mud pan became ignited. At 5 minutes the extinguisher operated. At 5 minutes 3 seconds the fire was out under the hood and on the ground. Time of operation of extinguisher about 9 seconds.

TEST NO. 3.

In this test a 16 inch fan operated by an electric motor was set up about 6 inches in front of the radiator so as to force air through the air passageways in a manner similar to that when the engine is operating the cooling fan.

Gasolene was ignited after flow had continued 2 minutes 50 seconds.

At 4 minutes 30 seconds the flow of gasolene was shut off because the flames extended underneath the entire length of the car and it was judged that even if the extinguisher did operate it could not put out the fire. A Pyrene extinguisher was used to extinguish the fire of the floor and seat boards. Fire out at 6 minutes. Extinguisher failed to operate.

TEST NO. 5.

A 155° Grinnell head was used in this test.

With fan running as in No. 3. Gasolene was ignited after flow had continued 1 minute 15 seconds. At 2 minutes gasolene flow was shut off and the fan was stopped immediately after because the flames were blown under the car so as to endanger the woodwork. At 2:35 the extinguisher operated with very little fire left. The fire was extinguished. Time of operation of extinguisher about 9 seconds.

CONCLUSIONS REGARDING THE USE OF AN ERWIN AUTOMATIC EXTINGUISHER ON AUTOMOBILE FIRES.

1.- METHOD OF APPLICATION.-

The liquid extinguishing agent in the tank is automatically discharged, in case of fire under the hood, on the lower surface of the hood and on other hot metal parts. This may be considered an effective method of application if the hood is down and the radiator fan is not running.

The operation of this extinguisher is automatic and in case of a fire the fusing of the solder on the strut of the sprinkler head permits the discharge of the liquid contents of the tank on the lower surface of the hood and into the space about the engine. In order to operate it is necessary that the fire be of sufficient magnitude to cause the fusing of the solder but the tests indicate that this is done before the wooden parts of the car are seriously endangered by the flames.

No tests were made of this extinguisher with the hood raised but it is considered very likely that, owing to the escape of heat, the sprinkler head would not operate promptly and that a fire, which could not be controlled by this type of extinguisher, would result before the solder was fused. The sprinkler head is provided with a deflector which distributes the fluid discharged in all directions and if the hood is up it is considered very probable that so large a proportion of the fluid would be

wasted that the extinguisher would have very little value under these conditions.

Test No. 3 and No. 5 indicate that, with the radiator fan running, a fire of considerable magnitude may be burning under the hood, but the hot gases are blown away from the sprinkler head so rapidly that it will not operate and a fire under these conditions may result in practically a total loss on the car.

2.- EXTINGUISHING EFFECTIVENESS.-

The tests of this extinguisher indicate that it is capable of controlling any gasolene or oil fire in which the burning material is confined to the space under the hood of an automobile and with a small quantity of inflammable liquid on the floor.

The results of the tests made, in which the extinguisher operated, were very satisfactory and the fire in each case was extinguished so promptly that it is reasonable to conclude that the entire space under the hood was filled with the vapors from the extinguishing fluid and justify the conclusion that a fire of any magnitude with the burning material confined to the space under the hood would be extinguished with this device installed on the car. This conclusion finds further justification in the fact that the quantity of carbon tetrachloride discharged is twice as great as that generally used in manually operated extinguishers.

3.- SUITABILITY FOR USE.-

The tests of this extinguisher indicate that it is suitable for use on automobiles to control fires occurring under the hood, but an auxiliary manually operated machine is desirable for use on fires which this extinguisher cannot reach or for use when the conditions under which this extinguisher is of little value are present.

The method of application of the extinguishing fluid is very effective largely because of the fact that, with the hood down, the extinguishing gases are confined and are able to promptly extinguish the fire.

The automatic operation of this extinguisher is a valuable feature because if a fire occurs when no one who knows how to use a manually operated extinguisher is about this device may be able to control it.

The extinguishing agent is a very volatile fluid and after it has operated the liquid evaporates so rapidly that it has very little opportunity to affect the parts with which it comes in contact.

Because of the fact that this extinguisher cannot have any effect on automobile fires not under the hood it is considered very desirable that an additional manually operated extinguisher be carried for use on these fires and also to supplement the work of the automatic device by extinguishing fires not completely controlled by it.

PYRENE LIQUID CHEMICAL FIRE EXTINGUISHER.

DESCRIPTION.

GENERAL. -

The main body of this extinguisher is cylindrical in shape. The extinguishing fluid is discharged by means of a manually operated pump.

The essential parts of this extinguisher are as follows:- A container (B), cylindrical in shape with hemispherical top and bottom; a pump cylinder (C) extending from top to bottom located in the center of the container; a piston tube (D) securely connected to the handle (L) at one end; a sliding piston (E) at the other end; the piston tube and sliding piston are enclosed in the pump cylinder; the outlet pipe (F) extends up in the piston tube and is rigidly secured at the bottom to the nozzle (J); two valve casings (G) and (G'), located at each end of the container, mechanically secured to and revolving with the piston tube and outlet tube respectively; a floating valve (H) which connects with the two valve casings; the valve stem (I) enclosed in a tube; a locking sleeve (K) which engages the handle (L); a filler cap (M) and nozzle (J).

CONTAINER. -

The cylindrical portion of the shell is made of sheet brass. In order that the container shall withstand shocks, three corrugations are made at each end of the cylinder to add stiffness. The enclosures for the ends of the cylinder consist of two sheet brass stampings. The ends of these stampings are flattened to provide a seat for the nozzle in

the lower stamping and a seat for the locking device in the upper stamping.

Two openings are provided in the upper stampings, one through which the piston tube passes and the other the filling opening. The latter is stamped with a raised boss which provides the seat for the gasket in the filler cap. The flange which projects from this opening is threaded and provides the means of attaching the filler cap.

PUMP.-

The pump cylinder is located in the center of the container. It is a tinned brass seamless tube. Slots are cut at each end of the tube, these slots being the inlet ports for the extinguishing fluid. The pump cylinder is held in position by the two valve casings (G) and (G').

The piston tube (D) is a tinned seamless brass tube and is threaded at each end. The threads at one end provide the attachment for the piston and the other end of the tube is securely attached to the handle.

The outlet tube (F) is a tinned seamless brass tube secured in position at its lower end only. It passes through the opening in the bottom of the cylinder and is soldered in position to the nozzle casting.

The sliding piston (E) is made up of three parts, two of which are of composition metal and the third a brass locking sleeve. The small casting over which the piston slides is shown in section on the blue print at (N). This casting is in the form of a tube threaded at one end. Two slots of rectangular form are located at diametrically opposite points and above the threaded end. This fitting is

provided with a flange at the other end through which the outlet tube passes. The fitting is threaded to the lower end of the piston tube and is locked in position by a brass ring. The sliding piston shown at (E) is a composition casting. It has an opening in the center which accommodates the above described fitting. In order to provide seats for the brass locking ring during the downward movement and the projecting flange of the fitting over which the piston slides during the upward movement, each face of the piston is recessed. During the upward travel of the piston that portion of the ports above the piston is open to the extinguishing fluid, and during the downward movement of the piston the portion of the ports below the piston allows the extinguishing fluid to enter the piston tube.

VALVE CASINGS.-

The rotating valve casings are of a composition metal, a large proportion of which is lead. They are held in position by the pump cylinder to which they are soldered at both ends. They are identical in form except having different size openings to accommodate the outlet and piston tubes. A circular brass stamping (8) is soldered to the edge of the opening and leaves a port (8') for the admission of the extinguishing fluid to the valve casing. The cylindrical portion (2) of the casing is reduced in diameter. At the inner edge of this opening is a ridge which provides the seat for the floating valve. A web with an opening in the center, through which the rod of the floating valve slides, is located at this end of the cylindrical opening. In the top of this cylindrical portion is an opening which is opened and closed by a bronze ball valve. Leading from this ball valve chamber is a port (7) which communicates with the port (8) which is the entrance to the pump

cylinder. Circular bosses are cast on the outer surface of the circular portion of the casings; these bosses are recessed for the gaskets which set up against the inner surface of each end of the cylinder.

FLOATING VALVE.-

The floating valve (I), supported by the two rotating valve casings, is for the purpose of closing the inlet port which is above the level of the containing fluid when the extinguisher is put into operation. It consists of a brass rod with circular discs (H) and (H') threaded to each end of it. The rod is supported at both ends in the center of the lower cylindrical section of the valve casings, and is enclosed in the space between these two casings by a sheet brass tube (3). This brass tube is slipped into the openings of the cylindrical portion of the valve casings and then soldered into position. The brass discs travel upward and downward and when at the end of their travel in one direction, one of the ports through the valve casing is open and the other is closed.

STUFFING BOX.-

The locking sleeve is a casting of composition metal which is soldered in position to the flat top of the brass stamping. This casting is in form of a washer having a boss with cast threads on its inner surface. Two locking lugs are located at diametrically opposite points and project from the upper surface of the outer edge of the casting.

HANDLE.-

The handle (L) is of composition metal threaded to the upper end of the piston tube.

This handle is the means of closing the outlet tube and also locking the extinguisher when not in use. The engagement of the lugs with the locking sleeve is limited to about a quarter of a turn by stops located at diametrically opposite points. A shoulder is located about 1-1/2 inches down from the top of the opening. This shoulder has an opening located in the center. The shoulder has for its upper surface a flat seat and the lower surface is beveled. This shoulder provides a seat for the cork (O). This cork provides for the closure of the outlet tube when the handle is locked. It is held against the shoulder by a coil spring (P) of German silver wire. The upper end of the coil spring bears against a brass screw plug.

FILLER CAP.-

The filler cap (M) is a casting of composition metal provided with a valve which opens inward and allows the admission of air to the interior of the shell whenever a partial vacuum is formed. The casting part of this cap is in the form of a plug. Two lugs are located at diametrically opposite points on the side of the cap. The valve is of composition metal, the upper surface being provided with a small circular recess which is held against a ridge, located around the central vent opening, by a coil of German silver wire.

NOZZLE.-

The nozzle (J) is a casting of composition metal and soldered in the recess in the lower end of the extinguisher. This casting has a circular opening through its center. The outlet tube is inserted in this opening and soldered in position. The diameter of the orifice is 3/16 inch.

DATA OF TESTS MADE TO DETERMINE THE EXTINGUISHING EFFICIENCY OF CARBON TETRACHLORIDE WHEN USED IN A ONE-QUART PYRENE EXTINGUISHER.

The data of these tests are arranged in groups.

G R O U P I.

These tests were made for the purpose of determining the ability of this extinguisher to control fires starting with a limited quantity of gasoline on the engine and in the mud pan. This condition might be the result of cleaning the car with gasoline or the gasoline might be spilled accidentally.

CONDITION OF TEST. -

A measured quantity of gasoline was poured on the carbureter from which part dripped on drip pan and on the floor. The gasoline was ignited with a match at a point near the carbureter. The hood on the carbureter side was up while these tests were being made. Neither the engine nor fan were running while these tests were being made.

TEST NO. 1.

1 pint of gasoline was poured on the carbureter most of which dropped into the drip pan and a small quantity on the floor. Extinguisher used 3 seconds after ignition. Operator attacked the fire about the carbureter and at the front part of the mud pan. The fire in the mud pan was then attacked from underneath the car. Fire was extinguished at 50 seconds. Weight of carbon tetrachloride used 2 pounds 14.9 ounces.

TEST NO. 2.
(Repetition of Test No.1)

Extinguisher used 3 seconds after ignition. Method of attack, the same as in Test No. 1. Fire was extinguished 37 seconds after ignition. Weight of carbon tetrachloride used 2 pounds 6.55 ounces. Sufficient gasolene remained after this test to burn for some time.

TEST NO. 3.

One quart of gasolene was poured on the carbureter and in the mud pan; about one pint dropped on the floor. Extinguisher used 3 seconds after ignition. Operator attacked the fire on the floor and at the back part of the mud pan. The fire about the engine and carbureter was then attacked and extinguished at 52 seconds. Weight of carbon tetrachloride used, 2 pounds 14 ounces.

TEST NO. 4.

Three pints of gasolene was poured on the carbureter and in the mud pan; about one quart dropped on the floor. Extinguisher used 3 seconds after ignition. Operator attacked the fire on the floor and at the back part of the mud pan. The fire on the floor was not extinguished, but the gasolene was swept from underneath the car and continued to burn at the side where it could not do any more damage. The operator then attacked and extinguished the fire about the engine and carbureter. Some more fluid was used on floor. Fire extinguisher exhausted at 61 seconds. Weight of carbon tetrachloride used 3 pounds 5.7 ounces. The gasolene on the floor was allowed to burn out.

This test indicates that three pints of gasolene burning may be considered the most

which can be controlled with the conditions under which these tests were made.

TEST NO. 9.

One half gallon of gasolene was poured on the carbureter and in the mud pan; at least a quart dropped on the floor. The gasolene was ignited with a match and was attacked about 3 seconds after ignition with a Pyrene extinguisher. There was so much gasolene burning on the floor that the flames extended to the back end of the car and it was readily apparent that the one quart of extinguishing fluid was not sufficient to extinguish the fire so the operator directed his attention to preventing the wooden parts from igniting and the gasolene was allowed to burn out.

G R O U P II.

The tests in this group were made for the purpose of determining the ability of this extinguisher to control fires starting after the gasolene line had become broken or the carbureter deranged so as to leak.

CONDITION OF TEST.-

A gravity feed gasolene tank was set up with the bottom 4-1/2 feet above the floor level and connected by a 1/8 inch pipe to a length of 1/8 inch hollow wire copper tubing which was led through the air passageways in the radiator and terminated above the carbureter. Under these conditions when the valve controlling the flow of gasolene was opened wide the rate of flow of fuel was about one half pint per minute. In these tests the valve was opened wide at the start of the test and was left open until the fire was controlled or the extinguisher exhausted. The

gasolene was ignited with a match after flow had continued a definite length of time, as indicated in the account of each test, and the extinguisher was used at the time noted. The hood on the carbureter side was up during these tests except as noted under Test No. 8. Neither the engine nor fan were running while these tests were being made.

TEST NO. 5.

The gasolene was ignited after flow had continued 2 minutes. Extinguisher was used at 2 minutes 3 seconds. Operator attacked the fire about the carbureter and front part of the mud pan and, when it was out there, the fire on the floor and at the rear end of the mud pan. Extinguisher was exhausted at 2 minutes 40 seconds. All the fire was extinguished except that at the rear end of the mud pan which was difficult to reach. The flow of gasolene was shut off when the extinguisher was exhausted and the gasolene was allowed to burn out. Weight of carbon tetrachloride used 2 pounds 12.8 ounces.

TEST NO. 6. (Repetition of Test No. 5.)

Gasolene ignited at 2 minutes. Extinguisher used at 2 minutes 3 seconds. Extinguisher exhausted at 2 minutes 23 seconds. The fire at the rear end of the mud pan was not extinguished. Weight of carbon tetrachloride used 3 pounds 5.8 ounces.

TEST NO. 7. (Repetition of Test No. 5.)

Gasolene ignited at 2 minutes. Extinguisher used at 2 minutes 3 seconds. Extinguisher exhausted at 3 minutes 1 second. The fire at the rear end of the mud pan was not extinguished. Weight of carbon tetrachloride used 3 pounds 4.5 ounces.

TEST NO. 8.

Repetition of Test No. 5, except that the hood was down on both sides, there being a crack, however, on the carbureter side between the lower edge of the radiator and the frame of the car about 2 inches wide because the hood did not fit the radiator very well.

Gasolene was ignited after flow had continued 2 minutes. Extinguisher was used at 2 minutes 3 seconds. Operator attacked the fire by directing the stream through air passageways in the radiator. When the fire was partially checked under the hood the fire on the floor was attacked and extinguished. A small flame at the point where the gasolene was flowing was then extinguished by directing the stream through the crack between the hood and the frame of the car. Fire was extinguished at 2 minutes 32 seconds. It was noted that the fumes from the extinguisher fluid remained under the hood and that some time elapsed before the residual gasolene could be ignited as the match was put out several times when the attempt was made. Weight of carbon tetrachloride used 2 pounds 5.5 ounces.

CONCLUSIONS REGARDING THE USE OF A PYRENE EXTINGUISHER ON AUTOMOBILE FIRES.

1.- METHOD OF APPLICATION.-

The method of using this extinguisher which consists of operating the handle like a pump and directing the issuing stream at the point desired may be considered an effective method of application.

Some pulsation of the stream was observed, due to the decrease in pressure on the fluid in the pump cylinder at each end of the stroke, but this was not considered sufficient to materially affect the accuracy with which the fluid could be directed nor to cause any appreciable loss of extinguishing fluid.

The range of this extinguisher is about 25 feet and this is considered to be sufficient for use on automobile fires.

2.- EXTINGUISHING EFFECTIVENESS.-

The tests of this extinguisher indicate that it is capable of controlling any fire starting about a car if it is applied before the woodwork is ignited to any considerable extent and if the amount of inflammable liquid on the floor is limited.

The extinguishing effectiveness of this fluid is due to the generation of heavy gases, when the liquid is discharged on a fire, which tend to exclude the oxygen and prevent further combustion. In view of the fact that an old car was used and that the area of the openings which might allow the escape of the gas was larger than generally found on automobiles it is considered that the tests indicated conclusively that the gases are confined sufficiently to extinguish any fire in which the burning liquid is confined to the car.

3.- SUITABILITY FOR USE.-

This extinguisher is considered to be suitable for use on automobile fires.

The extinguishing fluid can be accurately and effectively applied to the fire by means of this extinguisher and, if the extinguisher is used shortly after the fire starts it can be relied on to extinguish it.

The extinguishing agent is a very volatile liquid and after use on a fire in an automobile the liquid evaporates so rapidly that it has very little opportunity to affect the parts with which it comes in contact.

COMPARISON OF THE THREE EXTINGUISHERS TESTED.

1. - METHOD OF APPLICATION. -

Owing to the fact that the Pyrene extinguisher is manually operated and the stream may be accurately directed at any point desired the method of application of the extinguishing fluid is considered the best.

The Wolverine dry powder extinguisher is manually operated but, leaving out of consideration the lack of effectiveness of the powder, the method used for applying the extinguishing agent is considered inferior to the method used with Pyrene because it cannot be directed accurately and because the range is so short.

The Erwin automatic extinguisher is superior to the other two in the fact that if a fire occurs in a car, at a point near a sprinkler head, while no one is about, the sprinkler head will operate and, if the fire has not extended beyond the range of the head, the fire may be extinguished. This device is subject however to the following criticisms. If it operates with the hood up it is probable that a large proportion of the contents of the tank would be wasted. Leakage of air through the fill opening or leakage of liquid through the air inlet valve or the pipe connections may render the device inoperative. The area over which one head will distribute the fluid is limited and when the device operates all of the fluid is discharged very rapidly so if any fire is remaining at points about the car beyond the range of the head which operated it cannot be

extinguished. This extinguisher does not provide any means for attacking fires which may originate outside of the extinguishing range of any of the heads installed.

The Pyrene extinguisher is inferior to the Erwin only in the fact that being manually operated it cannot extinguish fires occurring when no one is about. This objection is considered to be of secondary importance however, because by far the greater proportion of automobile fires originate while something is being done on the car which is ignited. The superiority of the Pyrene extinguisher is due to the facts that it is operative at all times, that the danger of leakage or derangement of the parts is slight, and that it may be used on fires under the hood whether the hood is up or down.

2.- EXTINGUISHING EFFECTIVENESS.-

Of the two materials used as the extinguishing agents in these tests, the carbon tetrachloride is undoubtedly the more effective and the use of this fluid in a manually operated Pyrene extinguisher is preferable to its use in the Erwin automatic device.

The Wolverine dry powder extinguisher is effective only on fires in which the amount of burning material is so small that it is considered to be decidedly inferior to either of the types using carbon tetrachloride.

The Erwin automatic extinguisher, owing to the large quantity of fluid discharged, is probably the most effective on fires occurring within the range of the extinguisher. If the

fact, that the fire may spread beyond the range of the extinguisher, or that it may start at a point where no sprinkler head is installed, is taken into consideration, this device is inferior to one manually operated.

The contents of the Pyrene extinguisher may be discharged at any point desired and after operation has started it is not limited to one point of attack so it is considered to be the more effective of the two.

3.- SUITABILITY FOR USE.-

Either of the extinguishers, using carbon tetrachloride as the extinguishing agent, is considered suitable for use on automobile fires, but if only one type is to be installed the use of the Pyrene extinguisher is considered preferable to the use of the Erwin automatic device.

The Wolverine dry powder extinguisher is not considered suitable for use on automobiles because the extinguishing effectiveness is so low and because the operator may hesitate to use it on a fire under the hood because of fear of injuring the engine.

The use of a Pyrene extinguisher is considered preferable to the installation of the Erwin automatic extinguisher because the device can be used on a fire originating at any point in the car and it is very effective on any type of fire which may occur.

The installation of an Erwin automatic extinguisher, in addition to the Pyrene extinguisher, with sprinkler heads installed at

the points where fire is most likely to occur, is considered to be very desirable. With this arrangement the automatic device would extinguish fires within the range of the heads and the Pyrene could be used on any flames remaining after the operation of the automatic device or to attack fires originating at points where no sprinkler head is installed.

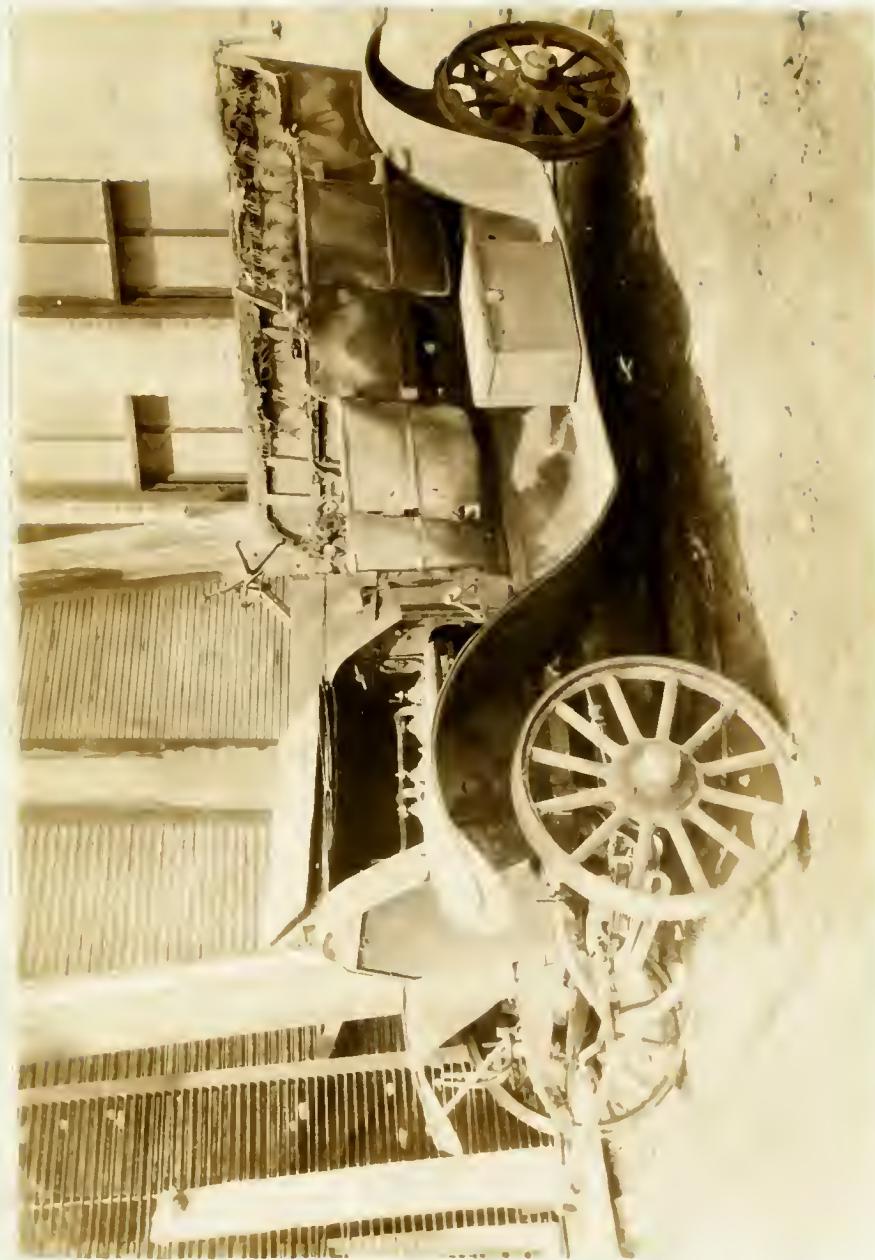
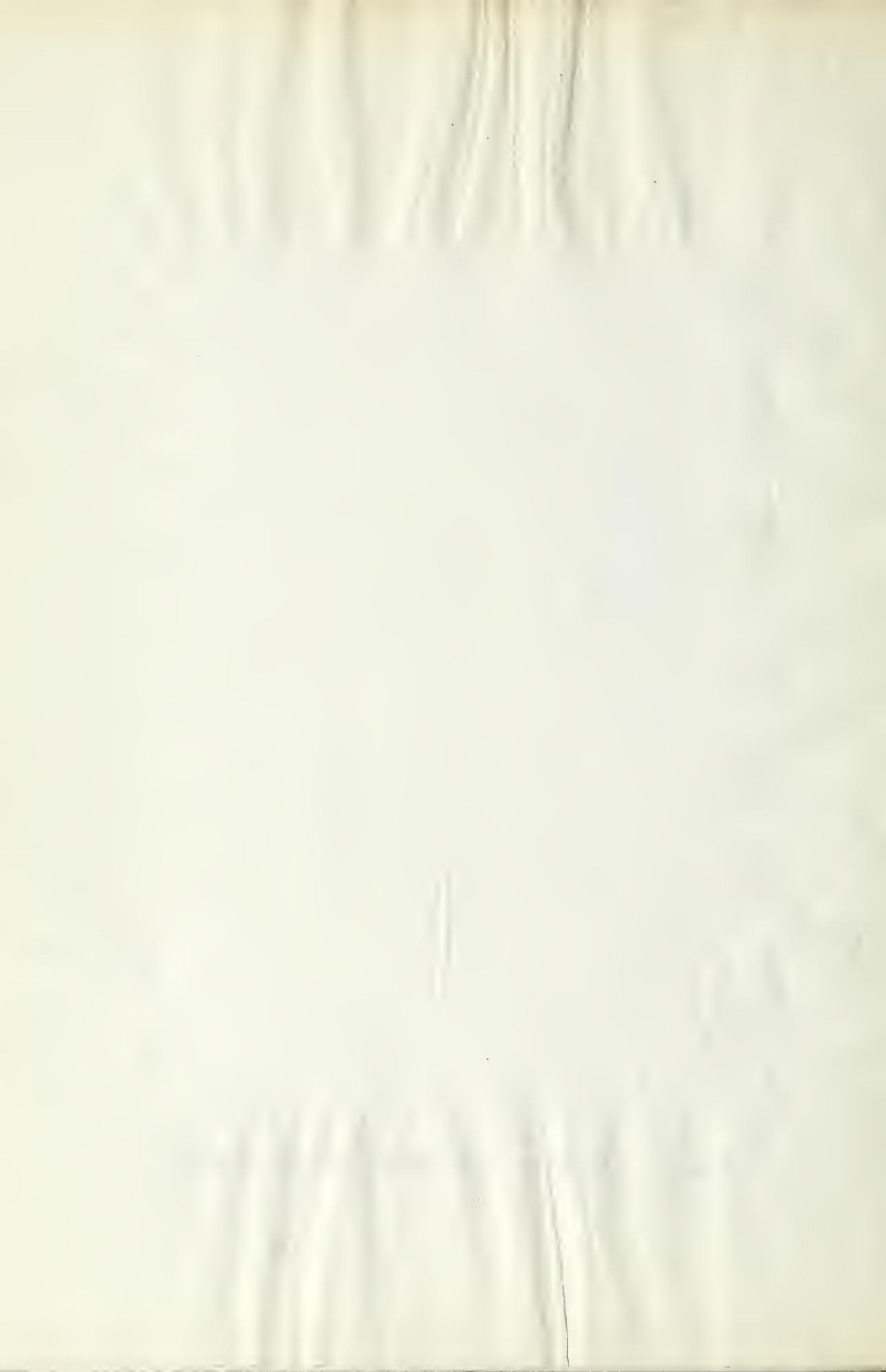


FIG. 1 AUTOMOBILE USED IN TESTS.



FIG. II WOLVERINE AND PYRENE EXTINGUISHERS.



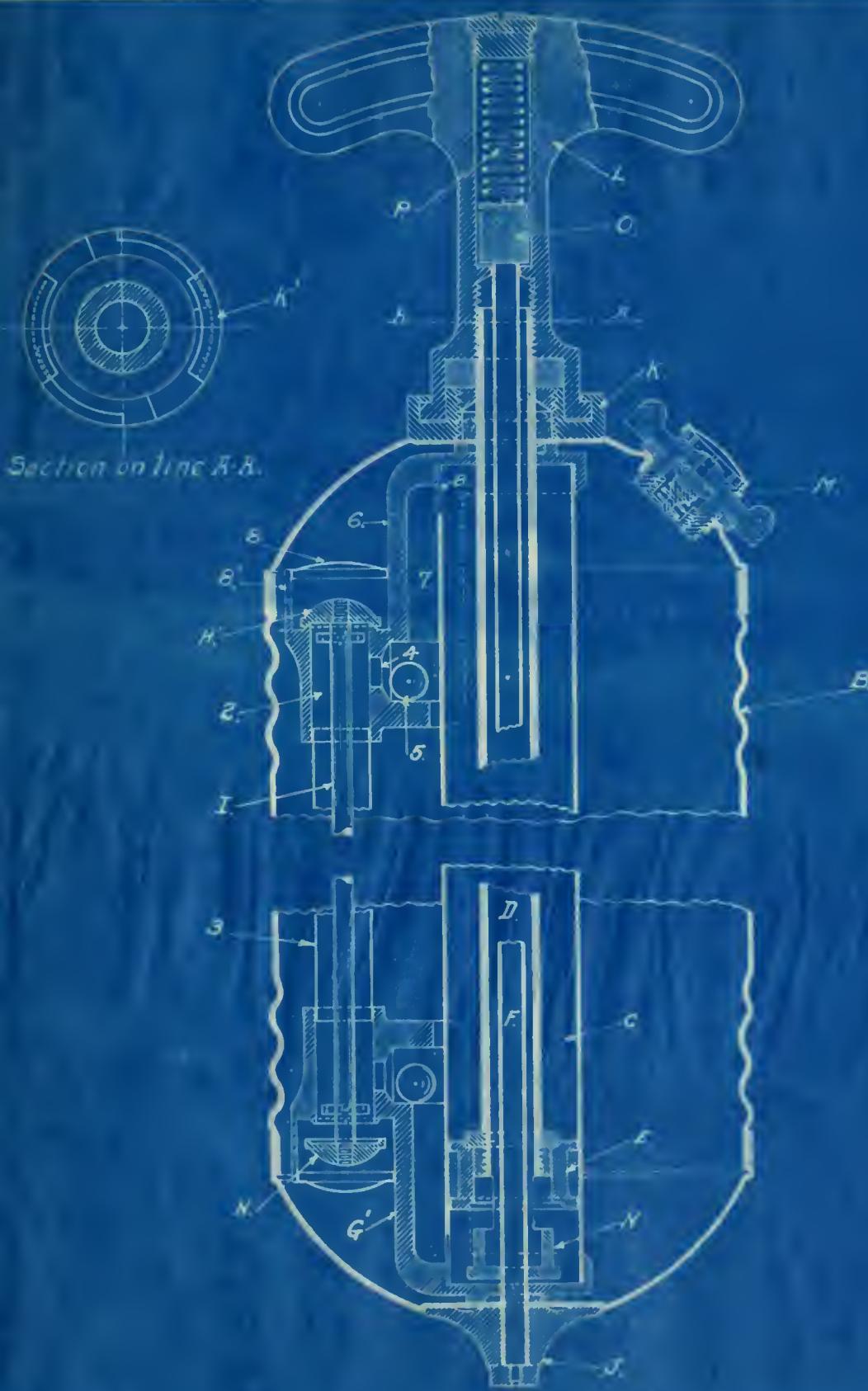


FIG. III PYRENE EXTINGUISHER.



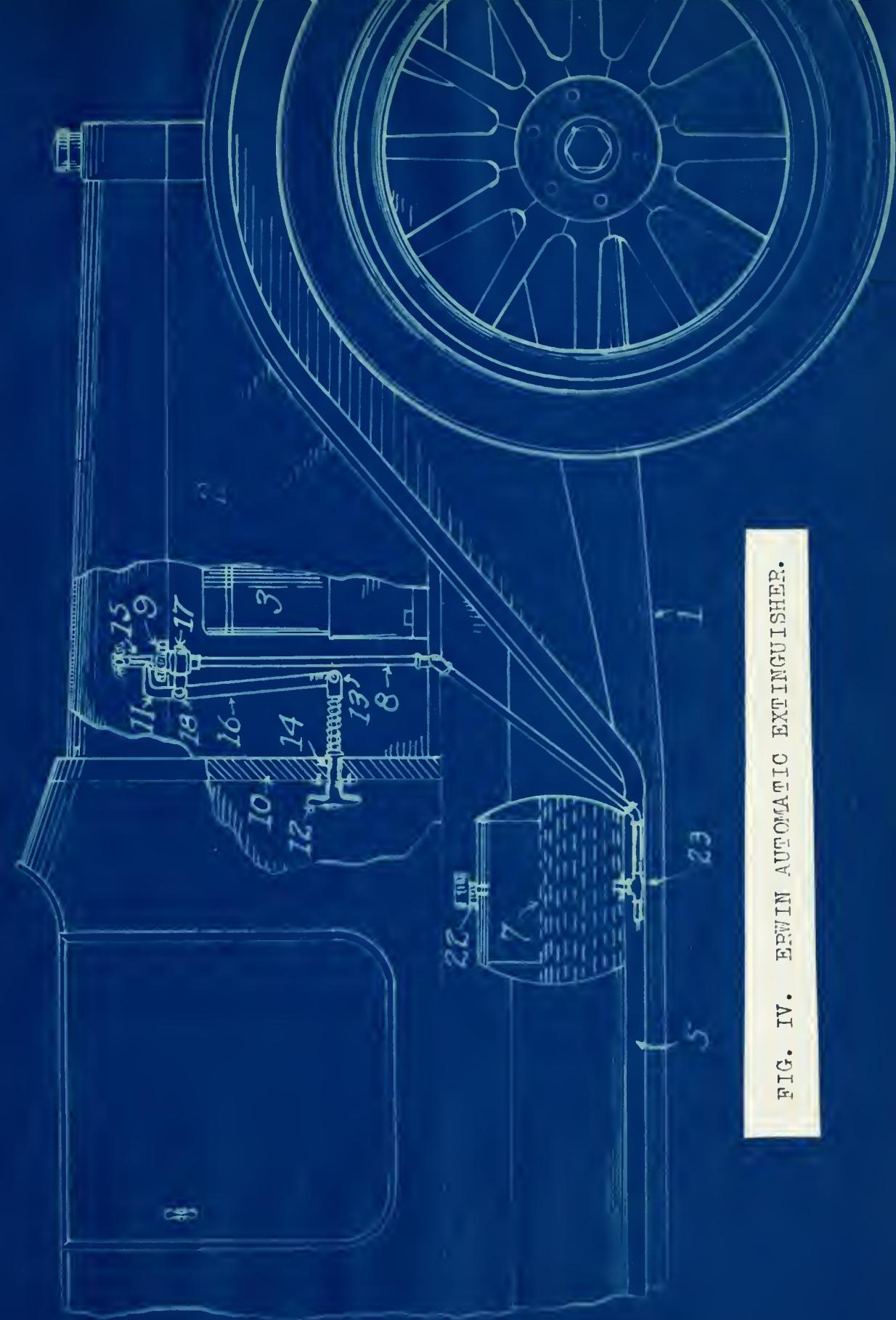


FIG. IV. ERWIN AUTOMATIC EXTINGUISHER.

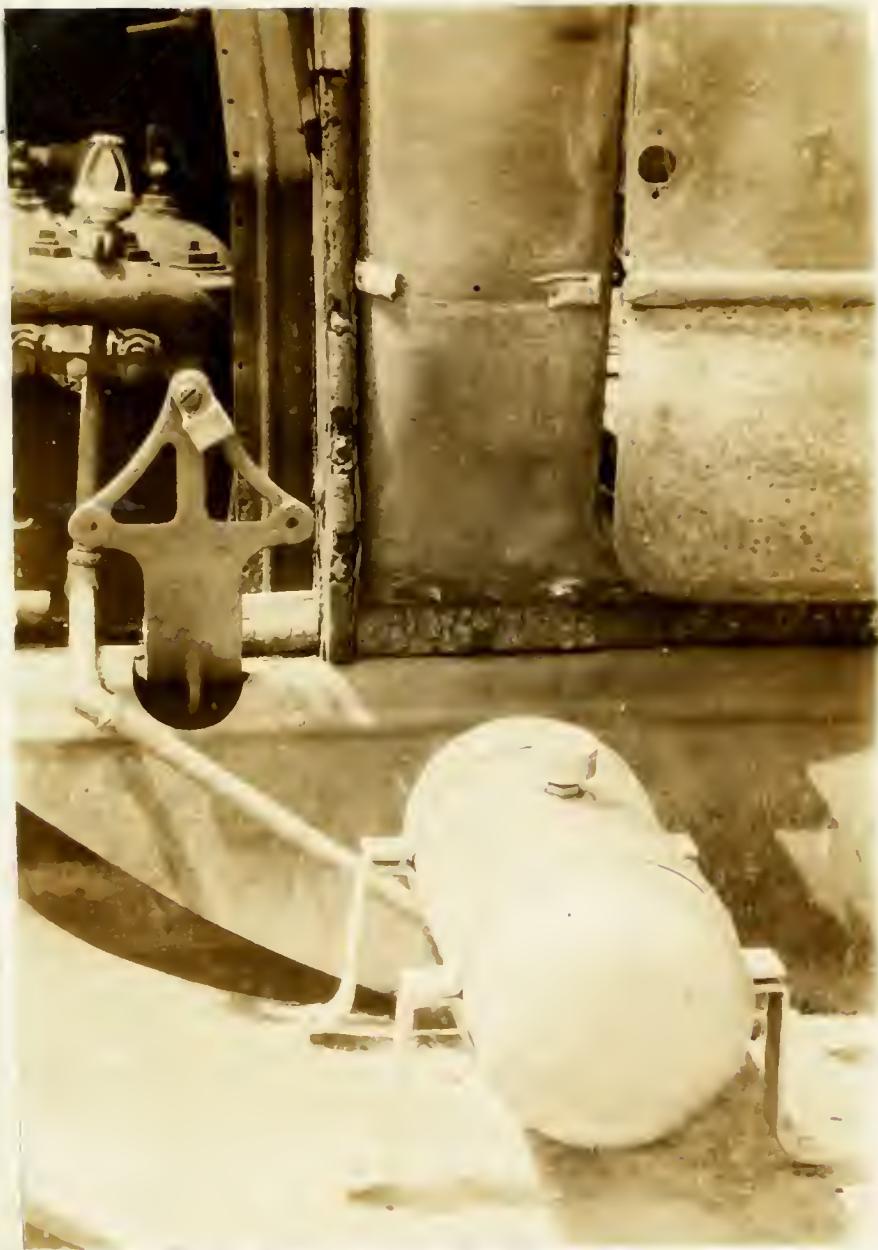


FIG. V ERWIN AUTOMATIC EXTINGUISHER
INSTALLED ON CAR.

